Quantifying Contact Rates and Space Use in the Eurasian Badger (*Meles meles*): Implications for the Transmission of Bovine Tuberculosis

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I certify that all material in this thesis which is not my own work has been identified, and that no material has previously been submitted and approved for the award of a degree by this, or any other university.

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“The Mole had long wanted to make the acquaintance of the Badger. He seemed, by all accounts, to be such an important personage and, though rarely visible, to make his unseen influence felt by everybody about the place”

- Kenneth Grahame, *The Wind in the Willows*

ABSTRACT

This thesis examines the space use, movement and contact rate patterns of a high- density, group-living, Eurasian badger (*Meles meles*) population in the UK naturally infected with bovine tuberculosis (bTB). Recently developed proximity logging devices were deployed on a representative sample of 51 badgers from eight different social groups to track their movements using radio-telemetry and to quantify their within- and between-group contact rates. Whilst interactions within social groups accounted for more than 90% of contacts, the entire study population was ultimately connected through interactions among individuals from neighbouring groups. Both within and between-group contacts, and also the use of denning sites, were heavily influenced by seasonal and demographic factors, which appear to be motivated to a large extent by reproductive behaviours. Nevertheless, by using social network analysis I found that badgers that tested positive for bTB were found to interact with fewer of their group members and for a shorter amount of time. Specifically these test-positive individuals were found to associate with test-negative group members significantly less than would be expected by chance. Those animals testing positive for bTB were also found to use outlying setts significantly more frequently than those that tested negative. The within and between-group contact rates of individuals were found to correlate with their sett use patterns. Those animals that spent less time interacting with group members and those that spent more time interacting with members of foreign social groups, were found to spend a greater proportion of their time at outlier setts. The findings in this thesis suggest a link between wider roaming behaviour and the disease status of an individual. This adds support to the argument that the social disruption of badger populations, for example through culling, may promote rather than alleviate the spread of bTB as a result of increased movement and contacts between groups. State-of-the-art technology has enabled me to demonstrate the strong influence that badger social organisation may have on the transmission of an economically significant infectious disease. My findings suggest that disease control measures might be enhanced by taking into account seasonal and individual-level variation in ranging behaviour and use of outlier setts, for example, by identifying and targeting functional groups of individuals, specific areas, or times of the year that contribute disproportionately to disease spread.

KEYWORDS: Eurasian badger, bovine tuberculosis, proximity loggers, contact rates, sett use patterns, social network analysis, individual-level heterogeneity.

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I dedicate this thesis to my family and husband.

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The trapping records for all badgers and the data for the baitmarking maps were collected and complied by Food and Environment Research Agency (FERA) staff. Bait deployment, badger trapping, sampling and release were carried out by FERA staff, assisted by myself over the course of my study. Chapter 2 was carried out in collaboration with J. Drewe from the Royal Veterinary College who provided and analysed the entire cattle collar data presented and co-wrote the manuscript. My supervisors and others credited in the acknowledgements commented on earlier drafts of this work and/or provided unpublished data that was used in various chapters (indicated in the text). With these exceptions, I declare that the work contained in this thesis is my own and has not been submitted for any other degree or award. Trapping, anaesthesia and biological sampling of badgers were carried out under licence from the UK Home Office (licence number PPL60/3609) according to the Animals (Scientific Procedures) Act 1986. All procedures were approved by the FERA Ethical Review Panel.

Nicola Reed